Exposure Assessment

using

Biomonitoring

June 29, 2004

Biomonitoring

assessment of internal dose exposure by measuring a toxicant (or its metabolite) in human specimens such as blood, urine, saliva, or adipose

Exposure and health effects pathway

External dose: air, water, food, soil, dust

inhalation
ingestion
skin absorption

Internal dose: blood, serum, urine, tissue

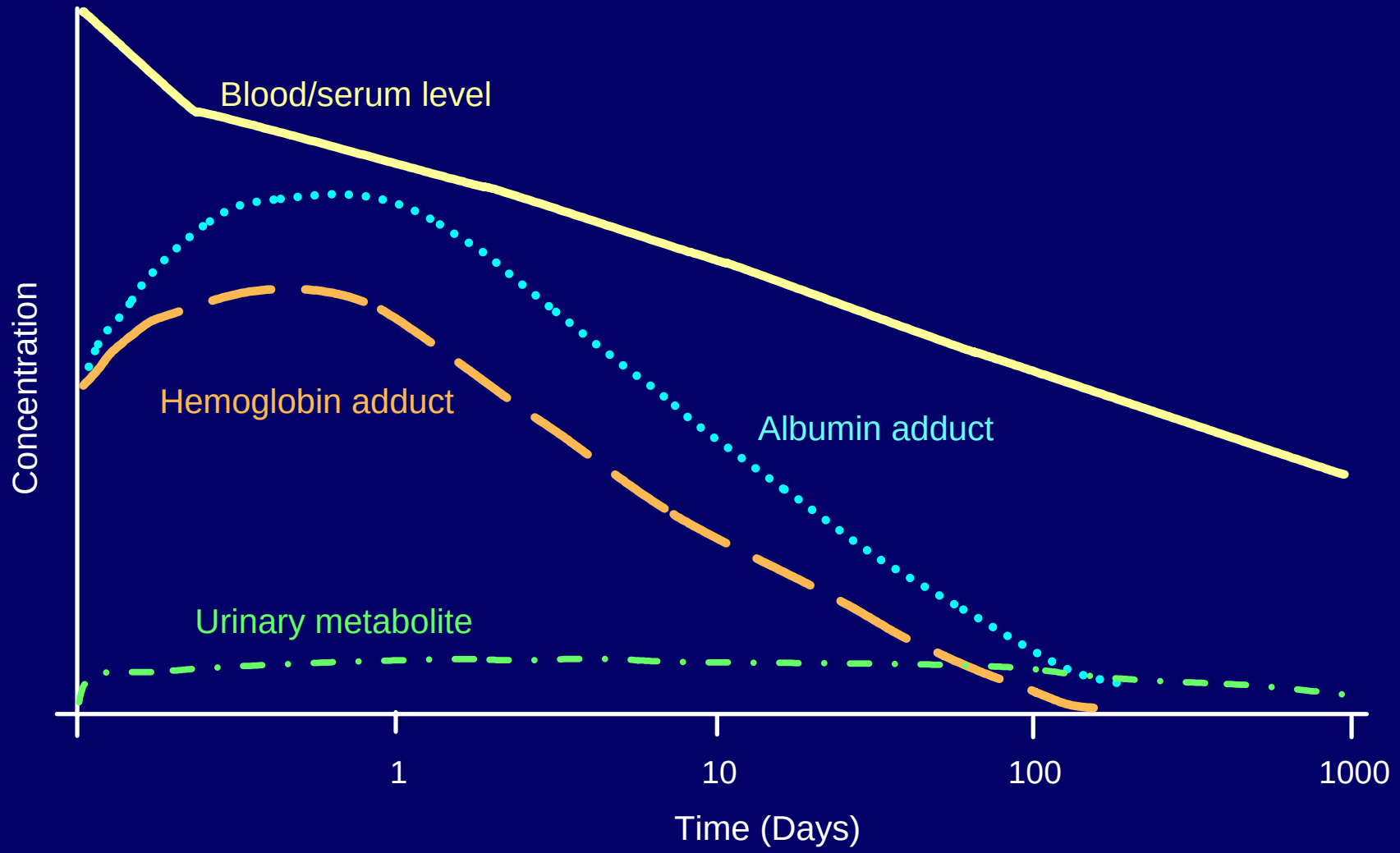
Health effect

Choice of matrix and form of chemical

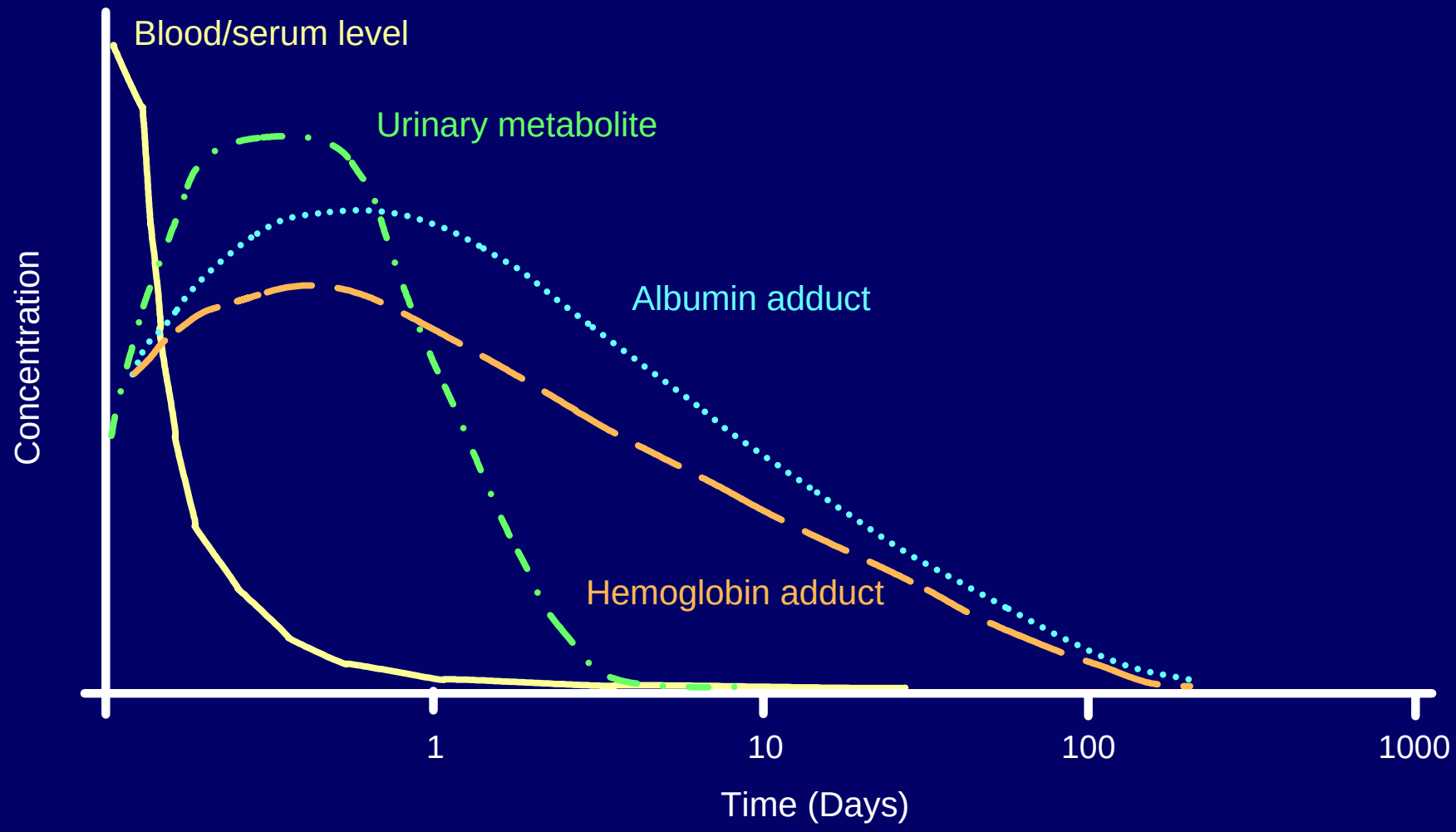
- Parent chemical in serum, urine, saliva
- Metabolite in serum, urine, saliva
- Protein adduct (albumin or hemoglobin) in serum or whole blood

Note the different exposure time frames represented by each of these measurements

Persistent toxicant in blood and urine



Non-persistent toxicant in blood and urine



Biomonitoring measurements can

CALIBRATE and **VALIDATE**

an exposure index based on other information

The exposure index can then be applied to many

people including persons who have died

Couple the right epidemiologic design to the appropriate biomonitoring measurement to answer the public health question of interest

Case control studies

Nested case control studies

Assessment of 20-30 potentially highly exposed

Multiple specimens collected over time to characterize time changes of an exposure

Cross sectional sample of population

Broad profile of measurements investigating a health effect of unknown cause (e.g., cancer cluster)

Identifying ‘unusually high’ exposures

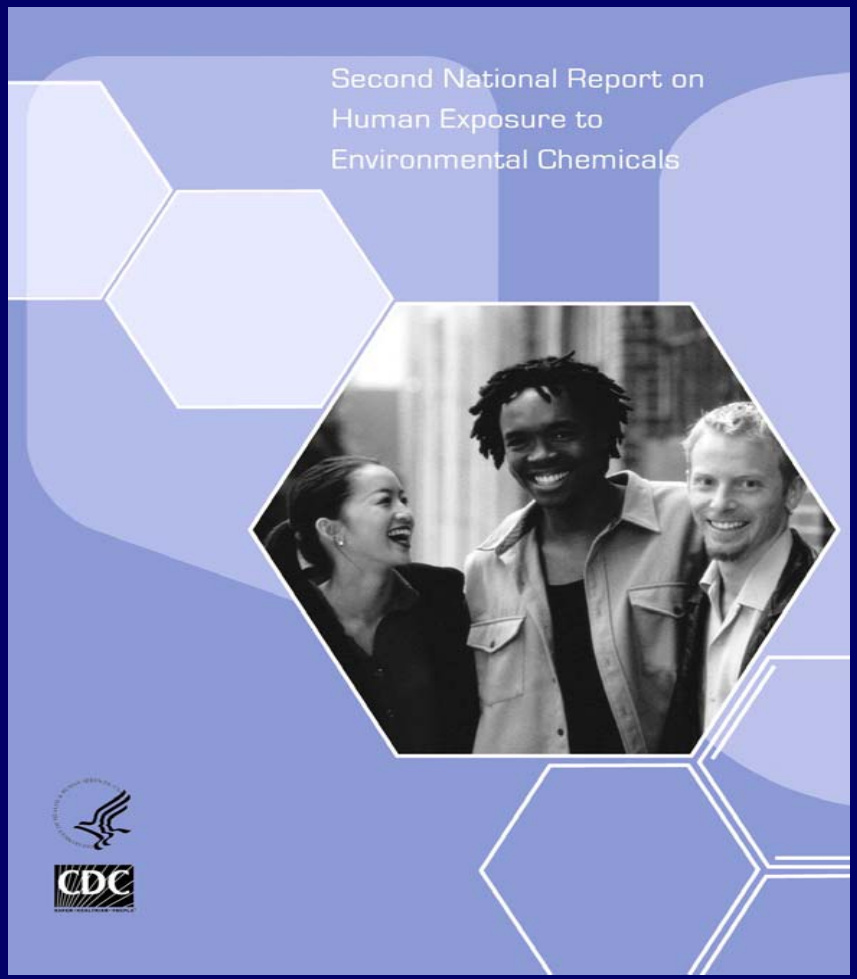
- Best if have health threshold level (e.g., lead $\geq$ 10 µg/dL)
- In absence of health threshold level, 95th percentile can be used to define ‘unusually high’ exposures

(see data from *Second National Report on Human Exposure to Environmental Chemicals*, 2003 at www.cdc.gov/exposurereport)

CDC's Second National

Report on Human Exposure

to Environmental Chemicals



Priority population groups for biomonitoring exposure assessment

- U.S. population and major U.S. demographic subgroups (today's presentation)
- Special population groups with known or suspected elevated exposures
- Special populations with disease known or suspected to result from chemical exposures

Report Data

- 116 chemicals
- Selected participants in NHANES 1999-2000
- Blood and urine levels of chemicals and metabolites
- Sample size: 2000-2500 (more for cotinine, lead, cadmium)

Chemicals in the *Second Report*

- Lead, mercury, cadmium, uranium, thallium, other heavy metals
- Cotinine (tobacco smoke exposure)
- Dioxins, furans, and coplanar PCBs
- Non-coplanar polychlorinated biphenyls (PCBs)
- Polyaromatic hydrocarbons (PAHs)

Chemicals in the *Second Report* *(cont'd)*

- Organochlorine pesticides
- Organophosphate and carbamate insecticides
- Herbicides
- Phytoestrogens
- Phthalates
- Pest repellants and disinfectants

Public Health Uses of the *Report*

- what chemicals get into Americans
- how many people have elevated levels
- effectiveness of exposure reduction efforts

Public Health Uses (continued)

- reference ranges – identifying unusual exposure
- levels in susceptible groups, like women of childbearing age or children
- priorities for health research

For chemicals with limited health risk information:

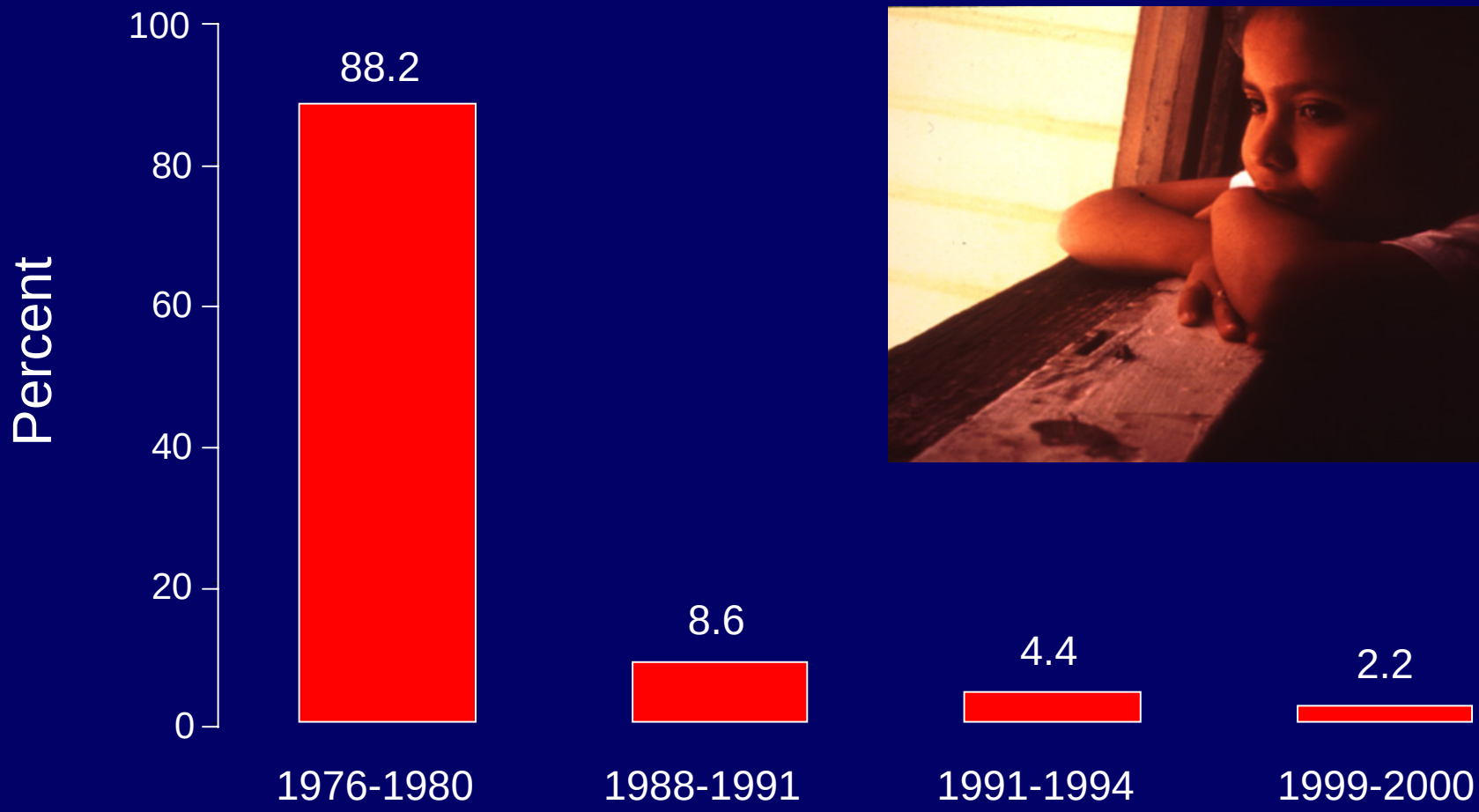
Just because we can measure it,
does *not* mean it is harmful

Table 58. 1-hydroxy pyrene

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

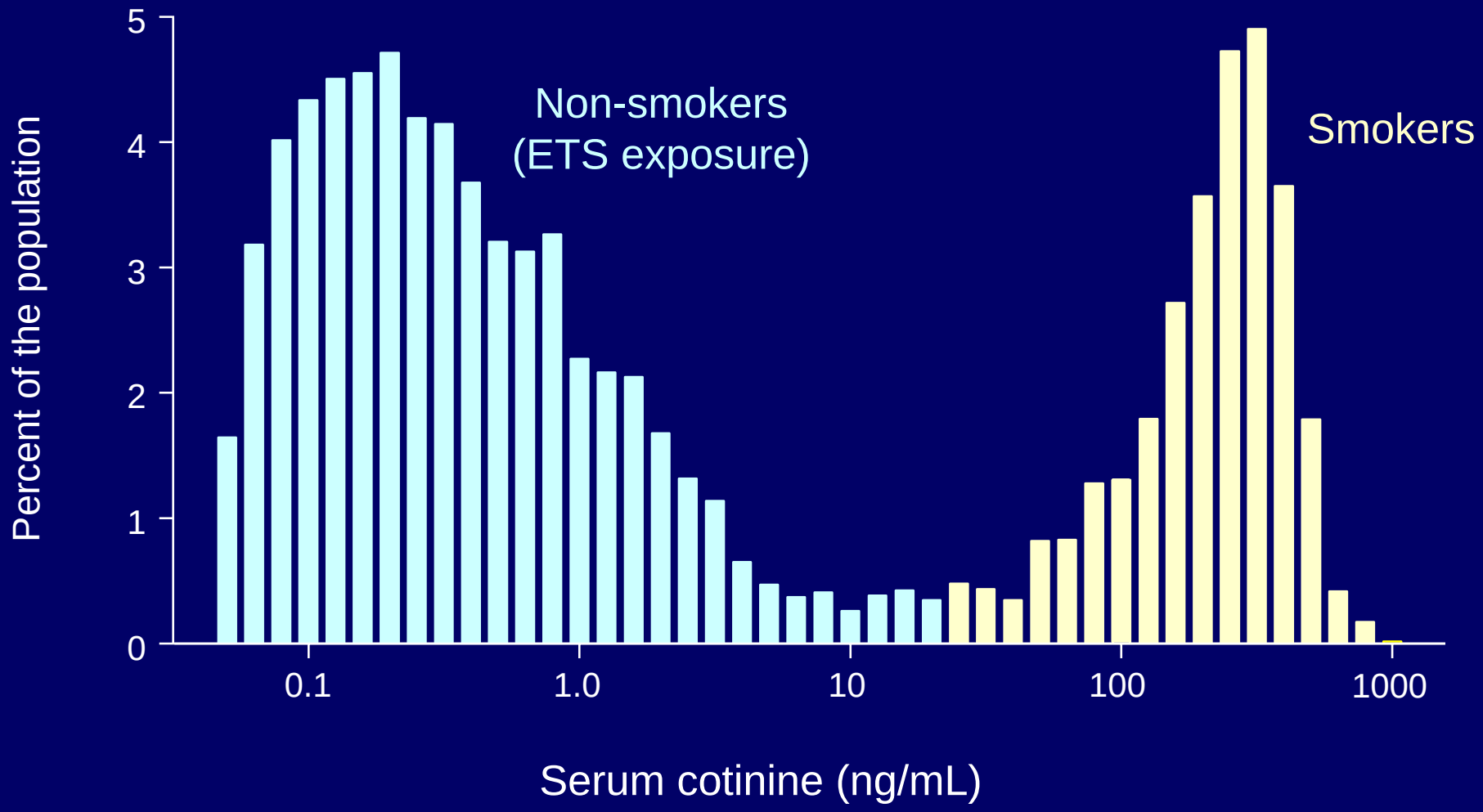
	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	79.8 (69.0-92.2)	14.9 (11.8-18.4)	34.8 (28.3-41.7)	78.0 (68.1-92.6)	187 (161-229)	434 (372-505)	730 (568-934)	2312
Age group								
6-11 years	90.8 (72.2-114)	18.6 (14.8-36.3)	55.7 (39.8-69.9)	91.9 (77.9-124)	170 (124-210)	299 (206-399)	413 (279-652)	310
12-19 years	105 (85.0-129)	24.1 (19.2-33.5)	48.0 (39.5-61.4)	108 (78.1-133)	226 (172-290)	473 (317-618)	642 (406-1170)	693
20+ years	74.8 (64.0-87.4)	13.6 (10.0-16.3)	30.7 (24.7-36.7)	70.1 (63.0-84.9)	187 (157-232)	446 (372-570)	795 (570-940)	1309
Gender								
Males	90.1 (76.0-107)	18.0 (14.1-23.5)	37.1 (30.0-48.6)	86.1 (73.2-99.8)	227 (178-282)	496 (401-577)	751 (577-1020)	1106
Females	71.2 (61.6-82.3)	13.7 (9.90-15.8)	32.1 (26.6-36.9)	70.9 (63.7-86.1)	163 (149-197)	361 (284-451)	669 (387-940)	1206
Race/ethnicity								
Mexican-Americans	74.2 (64.5-85.4)	16.1 (14.3-19.6)	34.0 (29.9-39.6)	68.3 (59.5-82.8)	161 (119-213)	344 (268-463)	545 (405-638)	766
Non-Hispanic blacks	108 (87.0-135)	20.8 (17.9-24.0)	46.6 (34.8-58.0)	100 (76.2-148)	245 (199-350)	586 (420-778)	812 (541-1360)	528
Non-Hispanic whites	73.7 (61.1-88.9)	13.8 (9.40-17.7)	32.3 (24.3-39.7)	72.9 (63.3-86.3)	178 (153-222)	399 (324-506)	748 (451-977)	831

Percent of children 1-5 years of age in the United States with blood lead levels ≥ 10 μg/dL

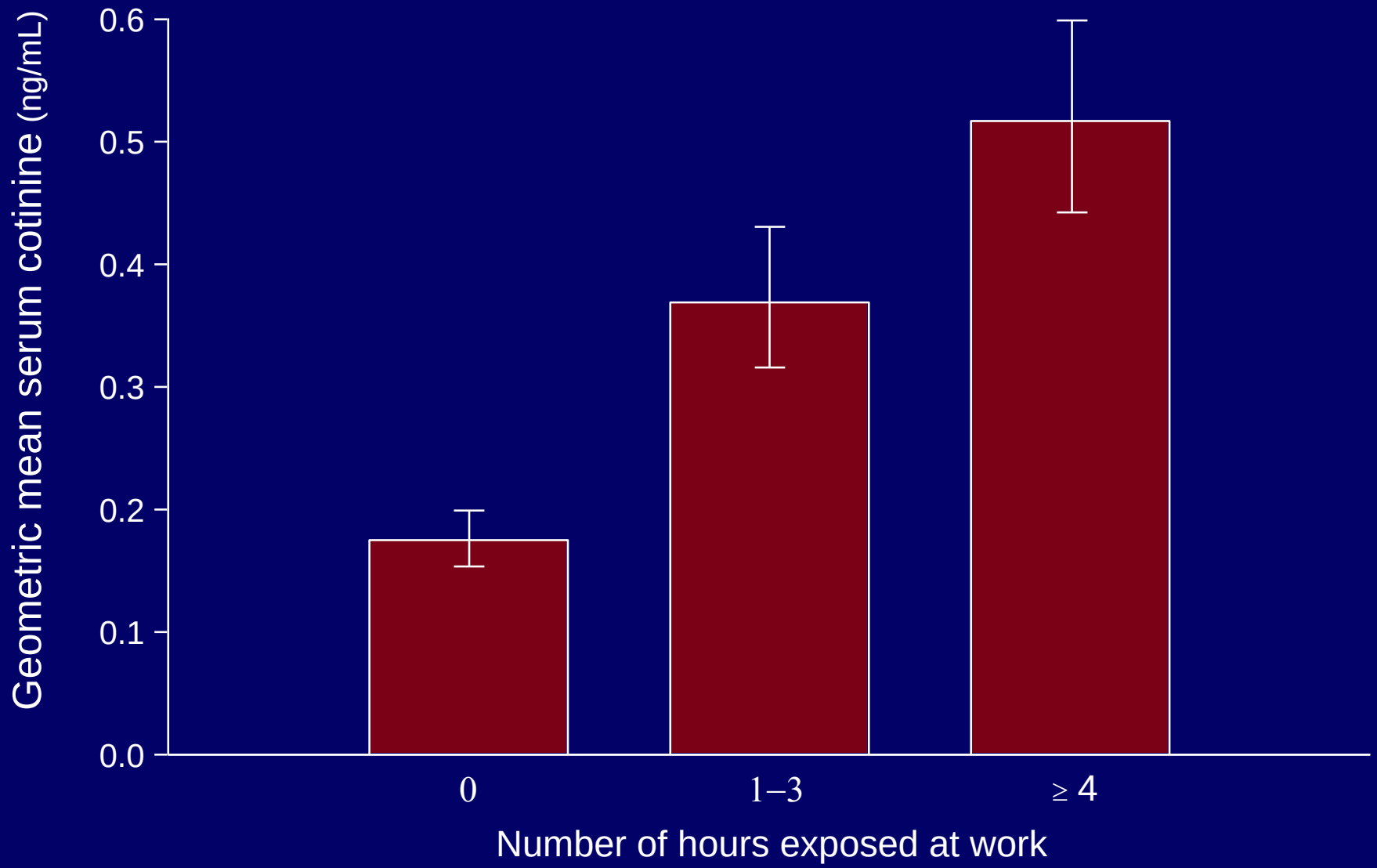


Exposure of the U.S. population to tobacco smoke:

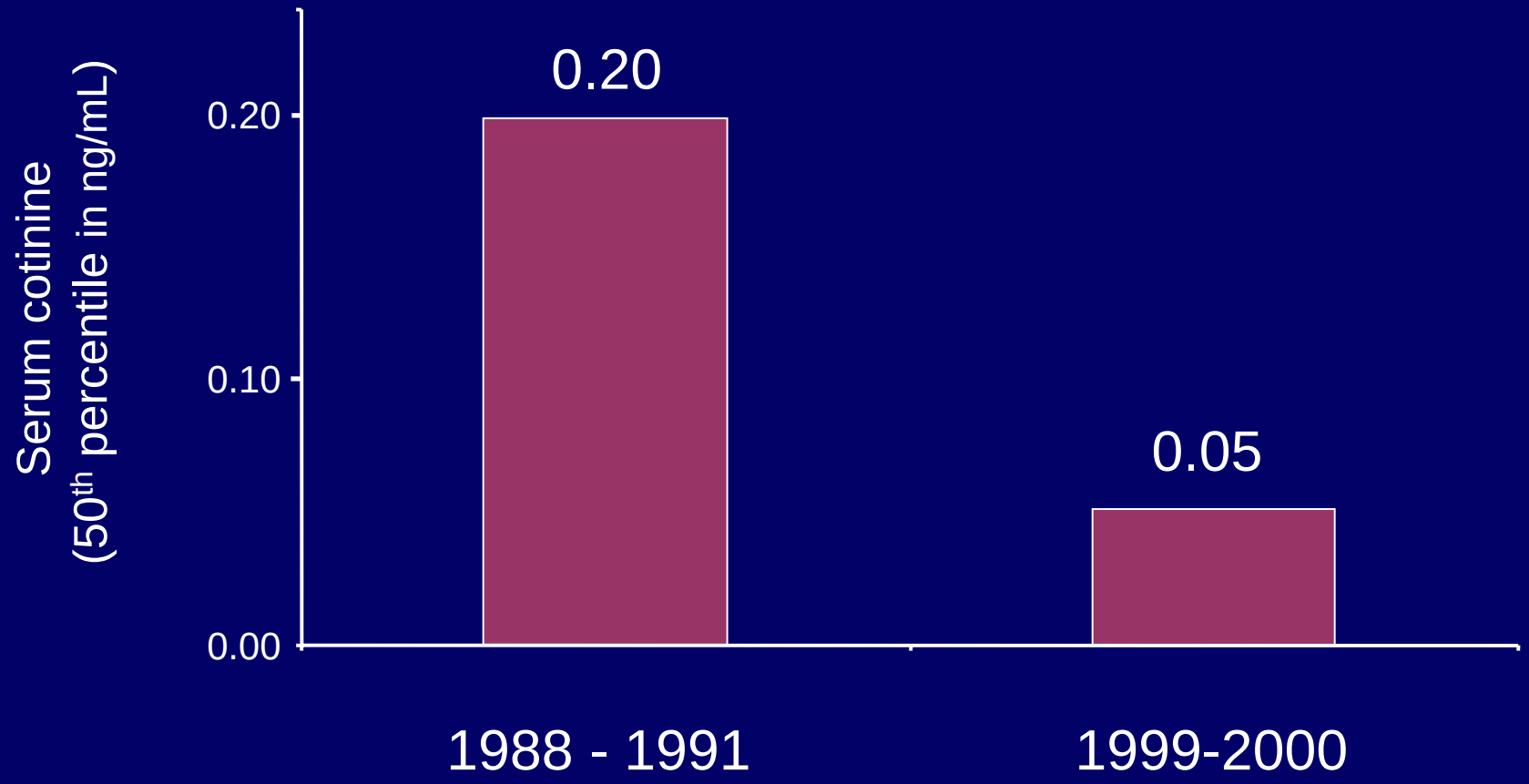
serum cotinine levels, 1988-1991



Serum cotinine levels for non-tobacco users in the U.S. population, ages 17 and older, NHANES III, 1988-1991



Decline in exposure of U.S. population to environmental tobacco smoke



Decline in cotinine levels by age group
(1988-1991 to 1999-2000)

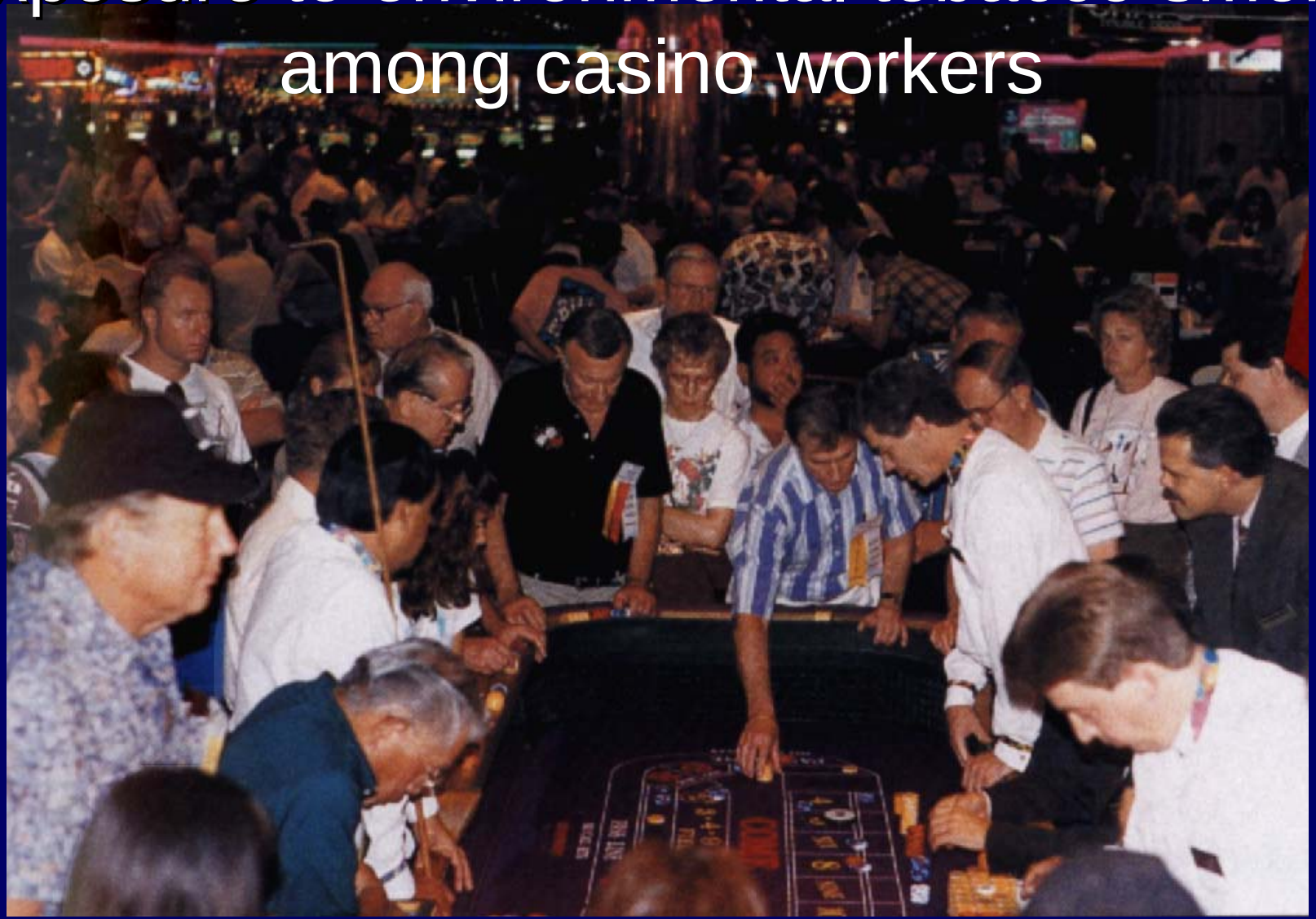
Children	↓ 58%
Adolescents	↓ 55%
Adults	↓ 75%

Cotinine levels, 1999-2000

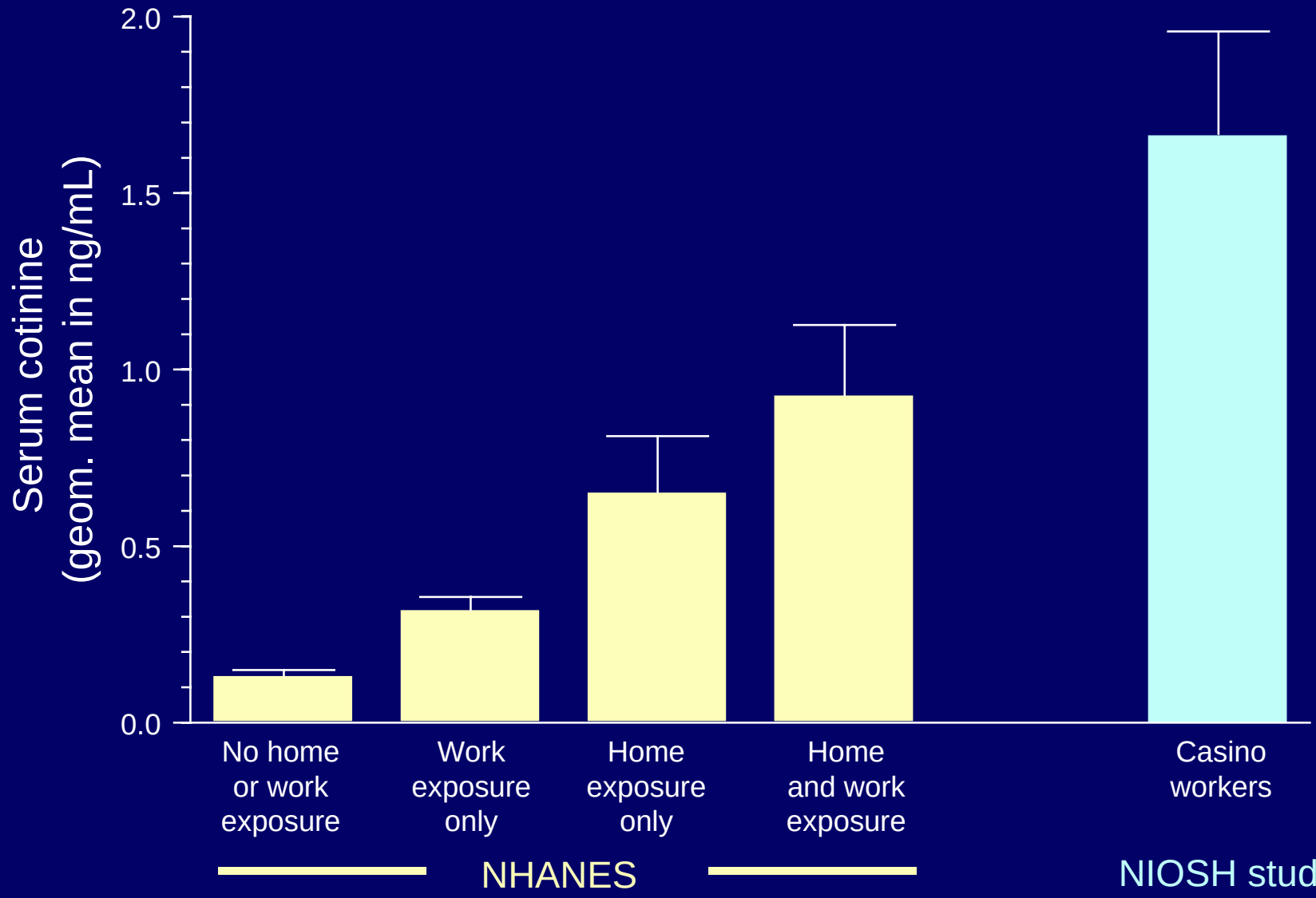
Children – levels more than 2X adults

Non-Hispanic blacks - levels more than 2X whites or Mexican-Americans

Exposure to environmental tobacco smoke among casino workers



Exposure of casino workers to environmental tobacco smoke



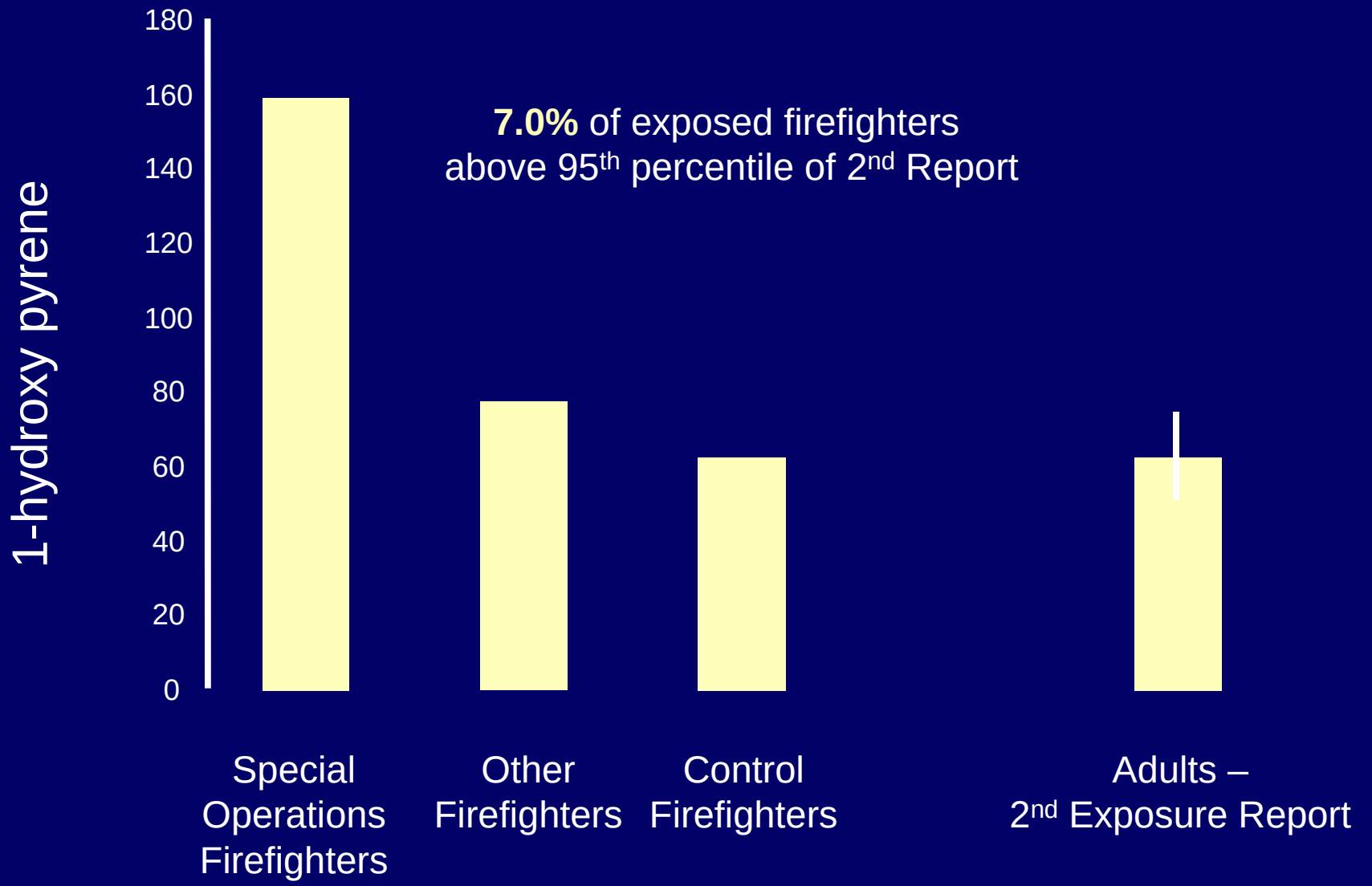
World Trade Center – detecting unusual levels of exposure

- 370 firefighters studied
- blood and urine samples collected while fires still burning
- 110 fire related chemicals tested

  PAHs
  Metals
  Cyanide
  Dioxins/furans/PCBs
  Volatile organic compounds

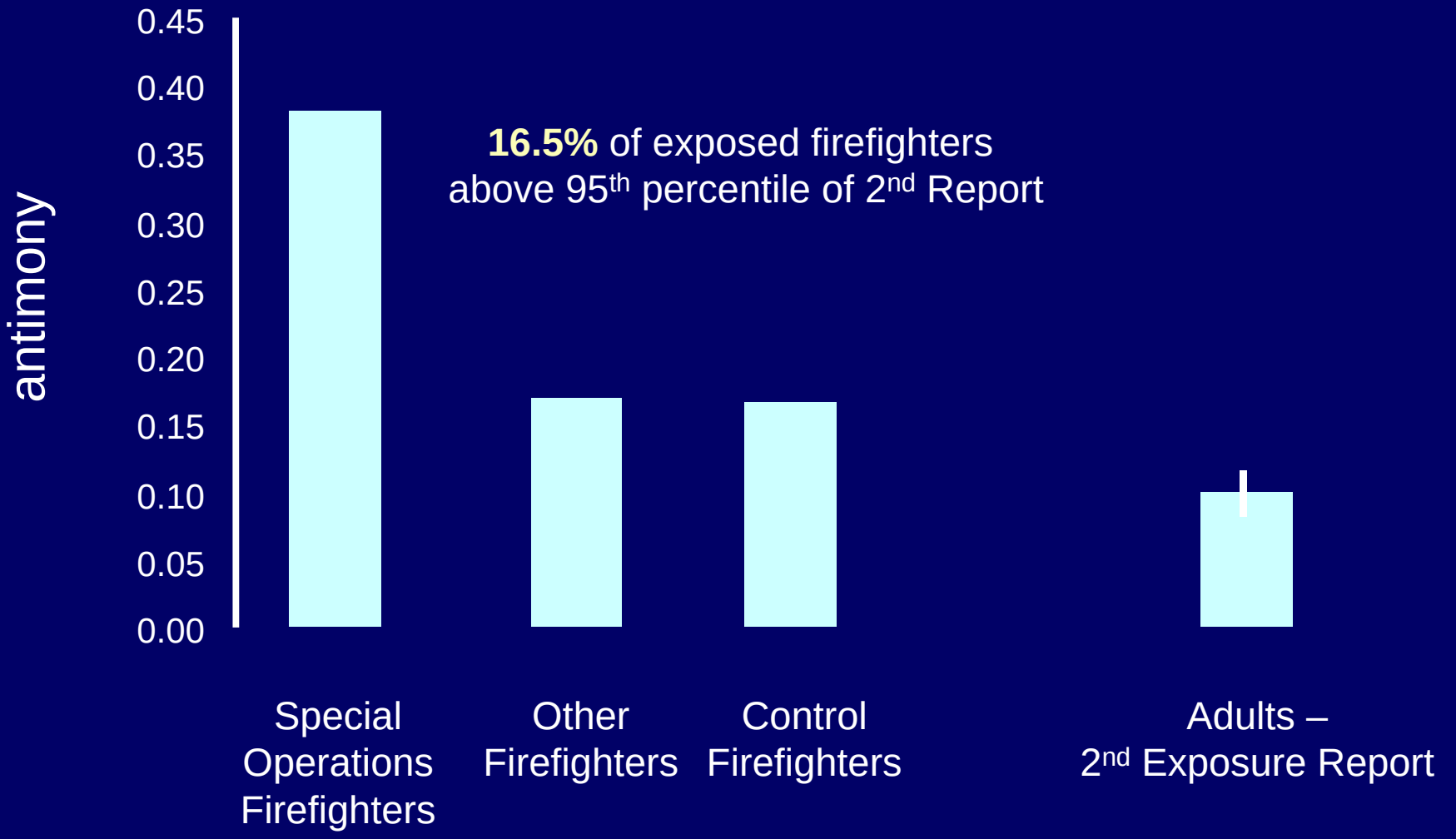
1-hydroxy pyrene levels in WTC firefighters

(geometric means in ng/L)



Antimony levels in WTC firefighters

(geometric means in μg/L)



U.S. troop exposure to depleted uranium in Iraq

- exposure from shrapnel
- exposure from battle explosions
- .045 μg/L is adult 95th percentile for urine uranium from 2nd *Report*
- to date, all soldier levels we have measured have been below this 95th percentile

Blood mercury levels in women of childbearing age (16-49 years), 1999-2000

- EPA reference dose for blood mercury is 5.8 μg/L
- In 2nd *Report*, the 95th percentile for women 16-49 years is 7.1 μg/L
- **7.8%** of women of childbearing age exceed the EPA RfD

Future Directions for the *Report*

- More chemicals
  - VOCs (benzene, MTBE, toluene, styrene, others)
  - perfluorinated compounds
  - polybrominated diphenyl ethers (PBDEs)
  - speciated arsenic
  - separate measurements for methyl mercury and ethyl mercury
  - perchlorate
  - acrylamide
  - PAHs with 5 and 6 rings, the more carcinogenic PAHs
  - more ….

- New *Report* every two years
  - (2001-2002, 2003-2004, 2005-2006, etc)

www.cdc.gov/exposurereport